

ALEX PROCEDURE

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FUNCTIONS: TRIG FUNCTIONS

PRIMARY KEYS: (2ND) (INV) SIN, COS, TAN

OP CODES: NONE

TEST PROCEDURE:

1) SPECIFIC TESTS:

ALL OF THESE FUNCTIONS WILL BE COMPARED TO VALUES GENERATED FROM THE IBM 360 USING QUADRUPLE PRECISION FORTRAN ARITHMETIC AND QUADRUPLE PRECISION ROUTINES FROM THE FORTRAN LIBRARY. A PROGRAM HAS BEEN WRITTEN FOR PRODUCT X TO COMPARE THE STANDARD VALUES AGAINST THOSE VALUES PRODUCED BY THE PRODUCT X FUNCTIONS.

- A) TRIGS - WILL BE TESTED IN 5 DEGREE INCREMENTS IN BOTH THE POSITIVE AND NEGATIVE DIRECTIONS BEGINNING AT 0 DEGREES. THIS TEST SHOULD HIT ALL OF THE "STANDARD VALUES" LIKE 30, 45, 60, 90, ETC. THIS TEST WILL BEGIN AT 0.0 AND GO TO 360.0 DEGREES.
- B) SMALL DEGREE INCREMENTS (.01) WILL BE TESTED AROUND 0.0-1.0, 89.5-90.5, 179.5-180.5, 269.5-270.5, AND 359.5-360.5.
- C) A CONTINUITY TEST WILL ALSO BE PERFORMED BY PROGRAMMING THE CALCULATOR TO CHECK FOR VALUES THAT DEVIATE RADICALLY FROM THE RANGE THE VALUE SHOULD FALL IN. THIS PROGRAM WILL CHECK THE VALUES GENERATED TO MAKE SURE THAT THERE ARE NO DIPS OR BUMPS IN THE "CURVE" GENERATED. THE GENERATED CURVE SHOULD CONSTANTLY INCREASE OR DECREASE IN A GIVEN QUADRANT.
- D) INVERSE TRIGS - WILL BE TESTED BY COMPARING PRODUCT X'S VALUES TO VALUES GENERATED FROM THE IBM 360. THE ARGUMENT VALUES FROM THE IBM ARE UNIFORMLY, RANDOMLY DISTRIBUTED VALUES BETWEEN 0.0 AND 1.0 FOR THE FUNCTIONS ARCSIN, ARCCOS, AND ARCTAN.

RANDOM NUMBERS WITH AN ABSOLUTE VALUE > 1.0 HAVE BEEN GENERATED TO TEST LARGE VALUES OF ARCTAN. A CONTINUITY TEST SIMILAR TO THAT PERFORMED FOR THE TRIG FUNCTIONS WILL BE PERFORMED HERE.

- E) THERE WILL BE A TEST FOR SIN AND COS ABSOLUTE VALUE ALWAYS LESS THAN OR EQUAL TO 1. THE CALCULATOR WILL BE PROGRAMMED TO PERFORM THIS TEST AT DEGREE INCREMENTS OF 0.01.
- F) MANUAL TESTING WILL INCLUDE CHECKS FOR VERY LARGE ARGUMENTS AND ARGUMENTS WHICH ARE LARGE MULTIPLES OF THE QUADRANT BORDERLINES. ALSO, THE RESULTS OF THE INVERSE OF A FUNCTION AFTER PERFORMING THE FUNCTION FOR VERY SMALL ARGUMENTS WILL BE CHECKED.

G) $\sin(x)/x$ AS $x \rightarrow 0$ WILL ALSO BE TESTED

- 2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, DEG, RAD, GRAD
- 3) PROBLEM ARGUMENTS: QUADRANT BORDERLINES (90, 180, 180, 360),
SMALL ANGLES, NEGATIVE ARGUMENTS AND
INVERTING THE COMPUTED VALUES.
- 4) ERROR CONDITION CHECK:
 - A) FOR SIN, COS, TAN: THERE SHOULD BE NO INVALID ARGUMENTS
 - B) FOR INV SIN, INV COS: ONLY VALUES FROM -1.0 TO +1.0
SHOULD BE LEGAL
 - C) FOR INV TAN: THERE SHOULD BE NO INVALID ARGUMENTS

PROBLEMS:

1. MORE EXTENSIVE TESTING OF THE TRIG FUNCTIONS (TESTING AT
SMALLER INTERVALS) CANNOT BE PERFORMED DUE TO TIME LIMITATIONS.

FUNCTIONS: LOGS AND ANTILOGS (BASE 10 AND NATURAL)

PRIMARY KEYS: 2ND (INV) LOG, LN

OP CODES: NONE

TEST PROCEDURES:

1) SPECIFIC TESTS

- A) ARGUMENTS FOR THE IBM'S LOG AND ANTILOGS ROUTINE WILL BE RANDOMLY GENERATED AND THE RESULTS WILL BE COMPARED TO THE VALUES GENERATED BY PRODUCT X GIVEN THE SAME ARGUMENT VALUES.
- B) VALUES FOR ARGUMENTS VERY CLOSE TO ONE AND ZERO WILL ALSO BE GENERATED ON THE IBM AND COMPARED TO PRODUCT X VALUES (VALUES WILL START AT 1.0 AND AT .00001 AND BE INCREMENTED BY .00001)

2) TEST MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, DRG

3) PROBLEM ARGUMENTS: THE LOG(X) OR LN(X) AS $X \rightarrow 1.0$ AND AS $X \rightarrow 0.0$
INV LN(X) AS $X \rightarrow -226$ AND $X \rightarrow 230$, $X \rightarrow 0.0$ (FROM BOTH SIDES)
INV LOG(X) AS $X \rightarrow -99$ AND $X \rightarrow 99$

4) ERROR CONDITIONS: ARGUMENTS WILL BE INPUT WHICH APPROACH AND EXCEED THE LIMITS OF THE FUNCTION (VALUES < 0.0 FOR LOGS.)
(VALUES < -226 OR > 230 FOR $E^{**}X$ AND < -99 OR > 99 FOR $10^{**}X$)

PROBLEMS: WHILE THE IBM FUNCTIONS ARE CONSIDERED TO BE VERY ACCURATE, THE RANGE OF QUADRUPLE PRECISION ARITHMETIC IS LIMITED TO APPROXIMATELY $10^{**}(-75)$ TO $10^{**(78)}$ WHICH IS LESS THAN THE RANGE OF THE CALCULATOR.

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FUNCTIONS: CONVERSIONS (P \leftrightarrow R, DMS \leftrightarrow D.DD, OP 18-20)

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PRIMARY KEYS: P \rightarrow R, INV P \rightarrow R, SWAP, DMS, INV DMS

OP CODES: OP 22-27

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TEST PROCEDURE:

1) SPECIFIC TESTS:

- A) ALL OF THE ABOVE FUNCTIONS WERE PERFORMED ON THE IBM 360 USING RANDOMLY GENERATED ARGUMENTS. THESE ARGUMENTS WILL BE USED AS INPUTS TO THE FUNCTIONS ON PRODUCT X AND THE RESULTS WILL BE COMPARED.
- B) P \leftrightarrow R WILL BE CHECKED MANUALLY ON QUADRANT BOUNDARIES .
- C) DMS \rightarrow D.DD WILL BE TESTED MANUALLY FOR VALUES WITH MINUTES AND SECONDS GREATER THAN 60.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG

3) PROBLEM ARGUMENTS: FOR P \leftrightarrow R WILL CHECK SMALL VALUES OF THETA
OP 18-20 WILL CHECK SMALL ANGLE CONVERSIONS

4) ERROR CONDITIONS: SHOULD BE ABLE TO ACCEPT ALL VALUES AS INPUTS
FOR P \leftrightarrow R AND DMS.
SOME LARGE VALUES MAY CAUSE PROBLEMS FOR
OPS 18-20.

PROBLEMS: LIMITED RANGE OF IBM QUADRUPLE PRECISION ARITHMETIC.

FUNCTIONS: FACTORIAL, ADD, SUBTRACT, MULTIPLY AND DIVIDE
SQUARE ROOT, POWERS, INTEGER POWERS, RECIPROCAL

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PRIMARY KEYS: 2ND ()!, +, -, X, DIVIDE, SQUARE ROOT, Y**X, ()N, 1/X

8/80

OP CODES: NONE

TEST PROCEDURE:

1) SPECIFIC TESTS:

A) FACTORIAL WILL BE TESTED COMPLETELY FROM 0! TO 69!
COMPARING THE VALUES GIVEN BY PRODUCT X TO THE EXACT ANSWER
GENERATED BY A SPECIAL 100 DIGIT STRING ARITHMETIC PACKAGE.

B) ADD, SUBTRACT MULTIPLY AND DIVIDE WILL ALSO BE TESTED
OVER A WIDE RANGE OF VALUES AND COMPARED TO VALUES WITH THE
SAME OPERANDS GENERATED BY THE STRING ARITHMETIC PACKAGE.

C) SQUARE ROOT, POWERS (INTEGER AND NON-INTEGER), AND
RECIPROCAL WILL BE TESTED OVER A WIDE RANGE OF VALUES
AND COMPARED TO RESULTS GENERATED BY THE IBM 360 USING
FORTRAN'S QUADRUPLE PRECISION ARITHMETIC. ALL ARGUMENTS
WILL BE RANDOMLY GENERATED BY THE IBM 360.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, HEX

3) PROBLEM ARGUMENTS:

A) LARGE FACTORIALS ARE LIKELY TO HAVE FEWER SIGNIFICANT
DIGITS THAN THE SMALLER FACTORIALS.

B) ARITHMETIC MAY HAVE PROBLEMS WITH VERY SMALL OR VERY
LARGE VALUES.

C) ZERO ARGUMENTS, NEGATIVE MANTISSA OR EXPONENT.

4) ERROR CONDITIONS:

A) FACTORIAL - VALUES LESS THAN 0 AND GREATER THAN 69
AND NON-INTEGER VALUES SHOULD CAUSE AN ERROR.

B) ARITHMETIC - CHECK FOR UNDER/OVERFLOW CONDITIONS
WHERE APPROPRIATE.

PROBLEMS:

1) FACTORIAL - NONE

2) ARITHMETIC - MORE EXTENSIVE TESTING SHOULD BE PERFORMED BUT,
THERE IS NOT A SUFFICIENT AMOUNT OF TIME TO COMPLETE
ADDITIONAL TESTING.

3) SQUARE ROOT, POWERS, AND RECIPROCAL - THE LIMITED RANGE OF THE
IBM 360 WILL NOT PERMIT VALUES ABOVE 10^{78} AND
BELOW 10^{-75} TO BE TESTED.

FUNCTIONS: INTEGER AND FRACTION FUNCTIONS

PRIMARY KEYS: INT AND INV INT

OP CODES: NONE

TEST PROCEDURES:

1) SPECIFIC TESTS:

A) BOTH INTEGER AND FRACTION WILL BE COMPARED TO 13 DIGIT VALUES GENERATED ON THE TI-990/10. THE IBM QUADRUPLE PRECISION ARITHMETIC IS NOT NEEDED SINCE NO ARITHMETIC IS BEING PERFORMED IN THIS CASE. THE TI 990/10 VALUES SHOULD BE ACCURATE TO APPROXIMATELY 14 DIGITS WHICH IS MORE THAN ADEQUATE IN THIS CASE. THE 13 DIGIT VALUES WILL BE RANDOMLY GENERATED BY THE TI 990/10.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, HEX

3) PROBLEM ARGUMENTS : VALUES WITH FRACTIONAL PORTIONS WHICH APPROACH 1.

4) ERROR CONDITIONS: NONE

PROBLEMS: NONE ANTICIPATED

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FUNCTIONS: ABSOLUTE VALUE, SIGNUM, CHANGE SIGN, UNARY MINUS

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PRIMARY KEYS: +/-, 2ND +/-, OP

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OP CODES: OP 10-11 (AS RECENTLY REVISED)

TEST PROCEDURE:

1) SPECIFIC TESTS

A) THESE FUNCTIONS WILL BE COMPARED TO VALUES GENERATED FROM THE TI 990/10 TO DETERMINE IF THEY PRODUCE THE CORRECT RESULTS FOR A WIDE RANGE OF VALUES
NEGATIVE POSITIVE AND ZERO VALUES WILL BE CHECKED.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, HEX

3) PROBLEM ARGUMENTS: VALUES NEAR ZERO FOR SIGNUM.

4) ERROR CONDITIONS: NONE

PROBLEMS: NONE

FUNCTIONS: STATISTICS FUNCTIONS

PRIMARY KEYS: SIGMA +, INV SIGMA +, SWAP

OP CODES: OP 31-39

TEST PROCEDURE:

1) SPECIFIC TESTS:

A) THE STATISTICS FUNCTIONS WILL BE CHECKED AGAINST STANDARD DATA SETS CONTAINING TYPICAL REGRESSION PROBLEMS.

B) THE STATISTICS FUNCTIONS WILL ALSO BE CHECKED WITH SOME BIZARRE DATA SETS (VERY LARGE AND VERY SMALL NUMBERS BOTH POSITIVE AND NEGATIVE).

***** THE PROBLEMS PRESENTED FOR BOTH A AND B WILL INCLUDE BOTH ONE AND TWO VARIABLE STATISTICS AS WELL AS TREND LINE ANALYSIS. THE ANSWERS FROM PRODUCT X WILL BE COMPARED AGAINST ANSWERS GENERATED BY THE IBM 360 PACKAGE 'REGRE' (A MULTIPLE REGRESSION PACKAGE)

C) SIGMA - WILL BE TESTED MANUALLY TO REMOVE THE LAST POINT ENTERED, POINTS WHICH WERE KEYED IN PREVIOUS TO THE LAST POINT AND REMOVING MORE POINTS THAN HAVE BEEN ENTERED.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, HEX

3) PROBLEM ARGUMENTS:

A) VERY LARGE OR VERY SMALL NUMBERS (THESE ARGUMENTS MAY ALSO CAUSE SOME DIFFICULTY WHEN TRYING TO GENERATE ANSWERS ON THE IBM FOR COMPARISON.)

4) ERROR CONDITIONS: OVER/UNDERFLOW CAUSED BY EXTREMELY LARGE OR SMALL NUMBERS.

PROBLEMS: TIME LIMITATIONS MAY RESULT IN INADEQUATE TESTING OF THIS FUNCTION.

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FUNCTION: PI

PRIMARY KEYS: 2ND PI

OP CODES: NONE

TEST PROCEDURE:

1) SPECIFIC TESTS:

A) FUNCTION WILL BE TESTED TO MAKE SURE THAT THE VALUE OF PI IS PRODUCED CONSISTENTLY.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT

3) PROBLEM ARGUMENTS: NONE

4) ERROR CONDITIONS: NONE

PROBLEMS: NONE

FUNCTIONS: DRG AND OP 12

PRIMARY KEYS: 2ND, DRG, INV

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OP CODES: OP 12

TEST PROCEDURE:

1) SPECIFIC TESTS:

A) DRG WILL BE CHECKED TO MAKE SURE THAT IT CYCLES THROUGH THE MODES DEG, RAD AND GRAD PROPERLY.

B) OP 12 WILL BE CHECKED ALONG WITH DRG TO SEE IF THE CORRECT MODE IS PROPERLY DISPLAYED.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, HEX

3) PROBLEM ARGUMENTS: NONE

4) ERROR CONDITIONS: NONE

PROBLEMS: NONE

FUNCTIONS: OP CODE DEFINITIONS

PRIMARY KEYS: 2ND DFN, OP

OP CODES: OP 0, DFN OP 0-77

TEST PROCEDURE:

1) SPECIFIC TESTS:

A) THESE FUNCTIONS WILL BE EXECUTED TO SEE THAT THE
CORRECT OP DEFINITION IS GIVEN.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, HEX, UNNORMALIZED

3) PROBLEM ARGUMENTS: NONE

4) ERROR CONDITIONS: NONE

PROBLEMS: NONE

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FUNCTIONS: ENTER EXPONENT, ENGINEERING NOTATION, FIX POINT

PRIMARY KEYS: EE, 2ND ENG, FIX, INV

OP CODES: NONE

TEST PROCEDURES:

1) SPECIFIC TESTS:

A) FIX WILL BE CHECKED FOR ALL VALUES 0-9 AND A-F TO SEE THAT THE PROPER NUMBER OF DECIMAL POINTS ARE DISPLAYED.

B) IFIX WILL BE CHECKED TO DETERMINE IF THE FIX FUNCTION IS SET TO THE SAME STATE THAT FIX 9 AND A-F WOULD SET IT TO.

C) EE AND ENG MODES WILL BE CHECKED TO SEE THAT NUMBERS CAN BE ENTERED PROPERLY IN THESE MODES AND THAT THE RESULTS OF CALCULATIONS IN THESE MODES ARE DISPLAYED PROPERLY. THE INVERSES OF THESE MODES WILL BE CHECKED ALSO.

2) MODES: MANUAL, PROGRAM RUN/STOP, HEX

3) PROBLEM ARGUMENTS: NONE

4) ERROR CONDITIONS:

A) FOR EE AND ENG - EXPONENTS > 99 OR < -99

B) FOR FIX VALUES OTHER THAN 0-9 AND A-F

PROBLEMS: NONE

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FUNCTION: SHOW OP CODE STATUS

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PRIMARY KEYS: OP

OP CODES: OP ~~20~~ 02

TEST PROCEDURE:

1) SPECIFIC TESTS:

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A) TEST OP ~~20~~ 02 TO SEE IF OP CODE STATUS
FOR OPS 3, 12, 16, 19, 43, 45, 60, 62, 64, 67, 69, 76
IS PROPERLY DISPLAYED.
THIS OP IS TO BE TESTED IN MANUAL MODE
AND IN RUN MODE.
IN MANUAL MODE THE MESSAGE WILL BE CHECKED
WITH THE STATE OF EACH OP TURNED ON AND OFF.
IN RUN MODE THE DISPLAY WILL BE CHECKED TO SEE
IF A 1 IS IN THE DISPLAY WHEN THE OP IS IN EFFECT
AND A 0 WHEN THE OP IS NOT IN EFFECT.

2) MODES: MANUAL, PROGRAM RUN/STOP, EE, ENG, FIX POINT, HEX, UNNORMALIZED

3) PROBLEM ARGUMENTS: NONE

4) ERROR CONDITIONS: NUMBERS LESS THAN 0 AND GREATER THAN 74

AND OP CODES WHICH DO NOT HAVE SPECIAL STATUS.

PROBLEMS: IT WOULD NOT BE POSSIBLE IN THE LIMITED TIME AVAILABLE TO TEST
ALL POSSIBLE COMBINATIONS OF OP CODES TURNED ON.

FEATURE PROBLEM DATE FOUND DATE FIXED DATE CONFIRMED

DMS INV DMS POSSIBLE ACCURACY PROBLEM 4/15/80 6/20/80 6/20/80
 5.25 DMS GIVES 5.416666667
 INV DMS GIVES 5.246
 THE 59 DOES THIS RIGHT
 ** NOTE. THIS TURNED OUT TO BE CAUSED BY A BUG
 IN THE INTEGER FUNCTION WITH CERTAIN
 VALUES DMS AND INV DMS ARE OK.

INV INT (FRC) POSSIBLE ROUND OFF PROBLEM 4/15/80 4/17/80 4/17/80
 5.999 999 999 999 INV INT=1.
 NOTE: THE TI 59 CAN NOT HANDLE AS MANY DIGITS
 IN THE DISPLAY AS THE TI-X BUT IT WILL DO THE
 SAME THING IF GIVEN AN INTERNAL VALUE WITH
 MORE THAN 10 DIGITS TO THE RIGHT OF THE DECIMAL.

D->R, D->G POSSIBLE ACCURACY PROBLEM 4/25/80 8/26/80 8/26/80
 COS(90->R)
 COS(90->G)
 CONVERTING 90 DEG TO RAD OR
 GRAD AND THEN USING COS
 GIVES:

- COS(90->R) = 8.967502 -13
- COS(PI/2) = -1.033235 -13
- COS(270->R) = -1.691224 -12
- COS(PI*1.5) = 3.089233 -13
- COS(90->G) = 1.570796 -13
- COS(270->G) = -1.570796 -12
- 90 DEG->R = 1.570796326794
- PI/2 = 1.570796326794
- 270 D->R = 4.712 388 980 38 5
- PI * 1.5 = 4.712 388 980 38 5

* NOTE: THESE COS(60 DEG) = .499 999 999 999 9
 2 BUGS ARE STILL COS(60 DEG -> 66.67 GRAD) = .500 000 000 000 1
 THERE.

LOG 1 LOG 1 = 4.342 945 X 10**16 4/29/80 7/29/80 7/29/80
 LN 1 LN 1 = 1 X 10** -15 4/29/80 7/29/80 7/29/80

5 BUGS FOUND TO DATE
 5 BUGS FIXED TO DATE
 5 BUG REPAIRS CONFIRMED TO DATE